



# Sensors and Automation

## Broadly Tunable Mid-Infrared Hydrocarbon Sensor

The petrochemical industry converts raw hydrocarbons into useful chemical products. During the energy-intensive industrial production of petrochemicals, the ability to detect and measure concentrations of individual gaseous hydrocarbons is of vital importance. Detection methods not only help facility operators fine-tune their chemical processes to ensure a high-quality end-product, they also alert operators to the presence of toxic chemicals that can be a health hazard to plant workers. For example, even trace amounts of acetylene can significantly harm ethylene production, while the presence of ethylene oxide, benzene, and formaldehyde in ambient air can pose a health hazard.

One of the most common analytical techniques, gas chromatography, presents a major disadvantage in that it cannot analyze processes in real-time because it requires that samples be taken and tested off-site. The resulting time delay means that undesirable or dangerous chemicals can remain in the flow longer, and therefore have more opportunity to cause damage. Researchers at Physical Sciences, Inc., are working to solve this issue through the development of a broadly tunable

mid-infrared sensor. This technology is integral for the development an *in-situ*, real-time process control system that will allow the end-products of industrial processes to be produced more safely and efficiently.



Although other commercial sensors use near-infrared lasers, general-purpose hydrocarbon sensors have not been adopted because much available laser technology does not operate at the appropriate wavelengths for hydrocarbon detection. The new technology has the desirable characteristics of other laser sources – such as power, ruggedness, compactness, ease of use, and cost – but will have the necessary addition of an increased tuning range.

### Applications and Benefits

Using this analyzer in process control is expected to save trillions of Btus annually in the petrochemical sector. Beyond process control and environmental monitoring, other potential applications for this technology include:

- Combustion emissions analysis
- Fugitive emissions control
- Contraband detection
- Improved safety conditions for plant workers
- On-site detection of chemicals

### Project Participants

- Physical Sciences, Inc. (Lead organization)
- Analytical Specialties, Inc.
- Dow Chemical
- U.S. Department of Energy, Small Business Innovative Research Program

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## Project Plans and Progress

**Project History:** This project was awarded under the SBIR solicitation. SBIR projects are conducted in multiple phases: Phase I awards were made in the spring of 2002, while Phase II awards were made in the spring of 2003.

### **Past Accomplishments**

In Phase I, researchers established the technical feasibility of developing a portable gas analyzer for petrochemical facilities based on a novel broadly-tunable mid-infrared laser source. Accomplishments of the now-completed first phase included:

- Selection of a gas (methane) to serve as the target gas for research.
- Design and fabrication of waveguide device that detects the target gas by generating broadly tunable mid-infrared radiation.
- Ability to measure power, tunability, and linewidth of tunable mid-infrared radiation.
- Creation of a conceptual design for a prototype spectrometer to be used in Phase II.
- Specification of a commercially significant mixture of hydrocarbons using the broadly tunable mid-infrared laser source.

### **Future Plans**

The second phase of the project will focus on developing a portable gas analyzer, measuring its properties, and testing its performance on a working petrochemical facility. To meet Phase II objectives, researchers will:

- Design, fabricate, and test optimized waveguides for efficient mid-infrared generation.
- Design and fabricate a portable prototype gas analyzer.
- Demonstrate speciation of calibrated gas mixtures.



## Sensors and Automation

The Sensors and Automation Activity (S&A), situated within the Industrial Technologies Program, develops and deploys integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors.

The industry sectors served by S&A are those that have established partnerships with the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy to collaborate in joint technology development for the competitiveness and vitality of the industry.

Work done under S&A will lead in providing the advanced measurement and control technology solutions to meet the needs of all industry sectors supported by the IOF strategy.

To learn more about S&A activities, visit the program web site at:

[www.oit.doe.gov/sens\\_cont/](http://www.oit.doe.gov/sens_cont/)

## A Strong Energy Portfolio for a Strong America

Energy Efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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